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WATER SUPPLY TREATMENT AT COUNCIL GROVE, KANSAS

By Louis L. Tribus

Among the first essentials in the practical training of engineers is to learn not to despise the day of small things, and to watch and note every strange phenomenon that catches the eye or ear. Countless small scale experiments in the laboratory have resulted in great accomplishments; small models usually exhibit in action the principles that govern full sized productions. More thought and skill are often required to secure efficiency and economy in the design and construction of the small public utility plant than for the much larger ones. Unnecessary first cost and a small annual waste in the one may be a much more serious burden than would be much greater freedom of original expenditure and a larger percentage of annual waste in the other. The writer therefore has no apology to make in presenting for record, and perchance for bringing out some helpful discussion, the following notes about a small water works plant at Council Grove, Kansas.

The real westerner is so accustomed to seeing big mountains, big plains and big rivers, that he naturally uses the big titles even though the object may be really small of its class. Council Grove therefore is a "city," though possessing less than 3000 inhabitants, but it has all the characteristics and aspirations of much larger confrères (Fig. 1). The Neosho River, which bisects it, has but 241 square miles of tributary watershed above Council Grove, yet exhibits many of the unfortunate water supply qualities of its friends and neighbors, the Missouri and Arkansas, which latter ultimately engulfs it, with some additional uncomfortable qualities thrown in.

The vicinity of Council Grove is typical "plains" region; rolling land with about 100 feet differences in elevation; some sharp ridges and many abrupt gulches; white limestone the abundant underlying and outcropping rock. The rock strata are not largely water bearing; gravel and sand deposits are scanty and so permeated with clay as to be of but small service for water storage. Such water as finds its way into the rock seams gradually works out into the river bottom as small springs, but not large enough or close enough together to repay collection.

The overlying soil is typical Kansas rich black loam and soluble clays. While trees and thick undergrowth are found bordering the river, there is nothing to hold back even ordinary rainfalls, so that the Neosho is very flashy by nature and receives from every storm overloads of sedimentary and partly soluble matters, the latter, present in colloidal form, very difficult of removal. During the middle winter, between storm periods, with consequently low level stage, the river water is clear and fairly potable, but very hard. As the floods come, the latter condition improves, but the silt and colloids make a compound to be shunned, if possible, as a public water supply, but at Council Grove it was "Hobson's Choice."

FIG. 1. MAIN STREET, COUNCIL GROVE, KANSAS

About 1886, franchise construction operators built a plant, without any treatment of the water, other than such settling as might take place in the receiving well, mains and standpipe. For ten years it served, however, to put out fires and fertilize the lawns. A few inhabitants whose house roofs could not yield sufficient rain water did use the supply, however, with the aid of faucet filters.

In 1897 the writer was called in consultation, but the company could not afford largely in the way of reconstructive expense; a dam was built across the river, raising the level about five feet, impounding 12,000,000 or 15,000,000 gallons or so, giving some settling effect (Fig. 2), and a pressure filter of "New York" type was installed, of rated capacity, 250,000 gallons per day. For a time these facilities served fairly well to meet ordinary consumption. Trouble came, however, in a few years, with the greatly increased use by the railroad shops and yards; the filter was unable to work rapidly enough, so that the mains became filled with scantily treated liquid, virtually nullifying the excellent filter action at ordinary rates of use.

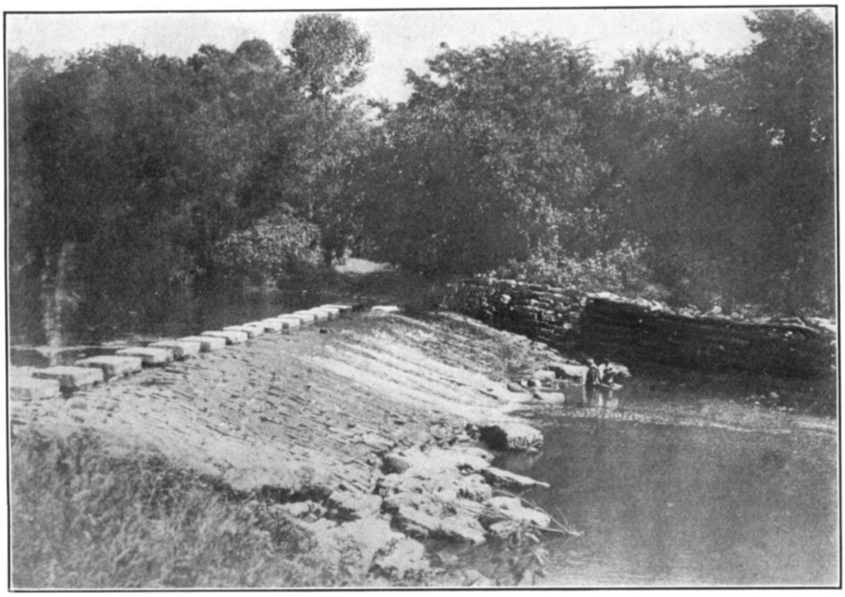


FIG. 2. MISSION DAM AT LOW WATER, SHOWING STEPPING STONES ON TOP OF CORE WALL. PAVED ROADWAY UPSTREAM FROM FOOTWAY

As the end of the twenty-five years franchise period approached, it was financially unwise to invest further moneys for an enlarged plant, particularly as negotiations were under way for the purchase by the city. The negotiations failed and litigation ensued, but finally adjustment of difficulties was secured by joint effort of law and engineering, and the writer's firm was authorized to design and carry out the necessary changes, which have been recently completed.

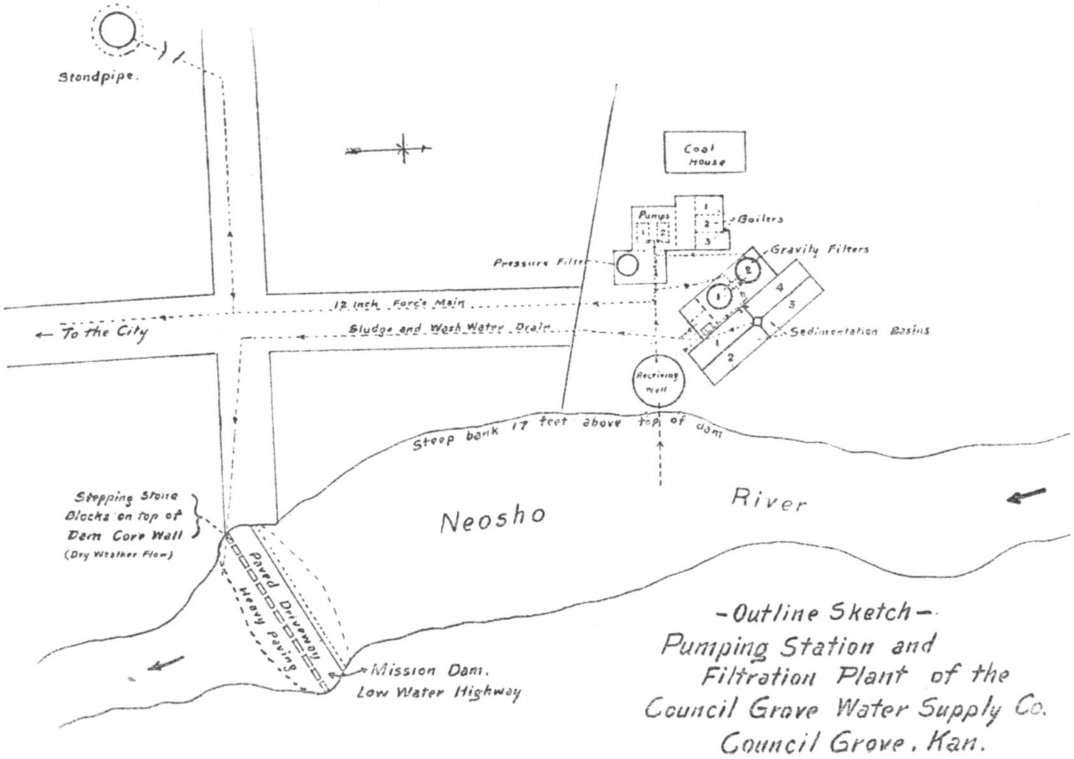
What time may demonstrate as continuing success under all conditions is unknown, but in the few months of operation, dealing some of the time with liquid mud, an effluent of zero turbidity has been delivered, while also meeting continuously the following test conditions.

> The test required for the filtered water shall be a reduction of bacterial content of at least 98 per cent from the content in the raw water, except that when the total number of bacteria is less than 3500 per cubic centimeter in the raw water, the filtrate must not contain in excess of 75 per cubic centimeter.
>
> The filtrate also must be without color, odor or turbidity, or free or decomposed alum, or aluminum hydrate.

During the past twenty-five or so years, the problems of water treatment have received great attention; those of Europe and the eastern United States have yielded under different methods and care practically perfect results as to potability and softness, but the western colloidal waters are still continuously under experiment with only partial success.

The writer does not consider the Council Grove plant ideal in design, for it had to be built to supplement existing works, but it makes possible the handling of the peculiar type of water available, with some degree of scientific care and with practical success.

Briefly described, the water flows through a pipe inlet into a deep 30-foot diameter river-side stone well, from which a 600,000-gallons per 24 hours centrifugal pump lifts it, a combined suction and discharge of 28 feet at low water, to sedimentation basin No. 1, or by cutout to the gravity filters direct. The overflow level of the basins is 3 feet above the sand in the filters. From basin No. 1, which it enters at one end near the bottom, the water flows nearly to the farther end through a low level submerged port connecting with basin No. 2, similarly flowing into No. 3 through a higher level port, and into No. 4 through an opening 18 inches below the upper surface of the water. From No. 4, at similar high level, though still submerged, the water passes to the two 250,000 gallons gravity, rake-agitated and clean-water-back-washed Jewell filters. In each basin, flow is also somewhat checked by cross baffles (Plates I, II III).



-Outline Sketch-
Pumping Station and
Filtration Plant of the
Council Grove Water Supply Co.
Council Grove, Kan.

PLATE I

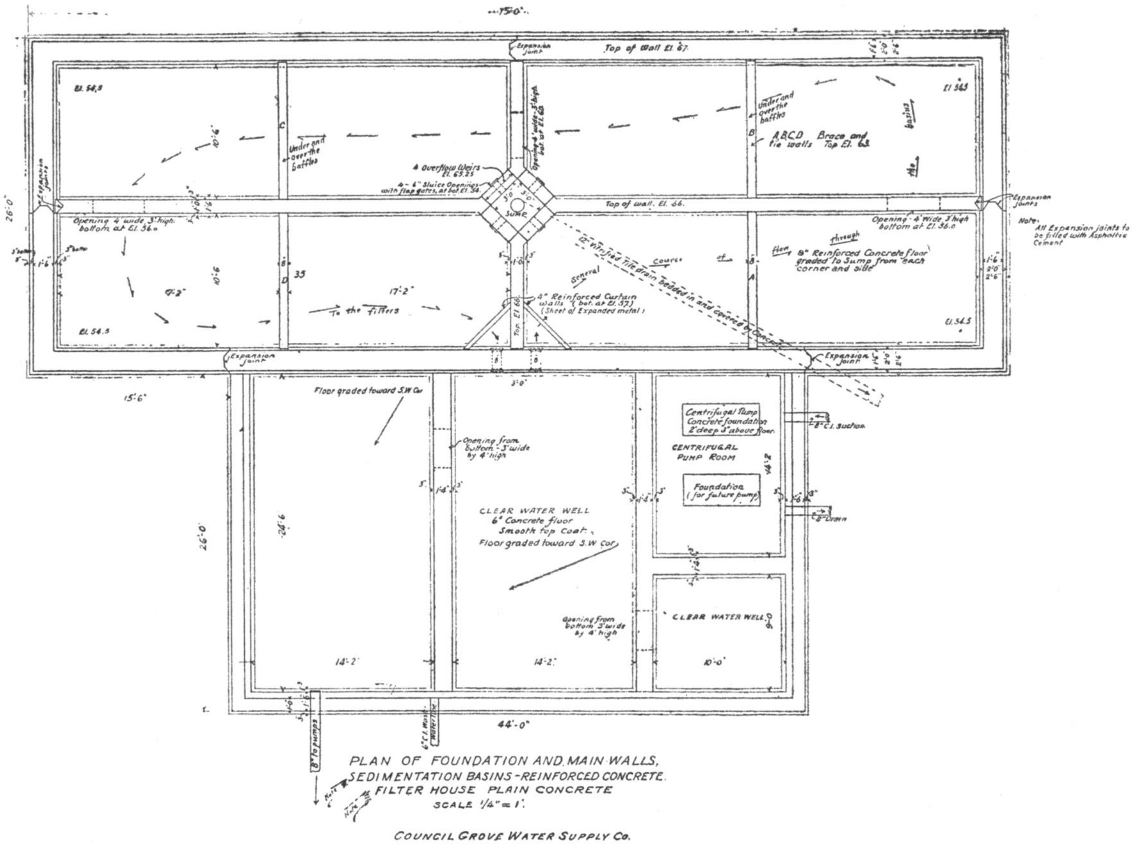
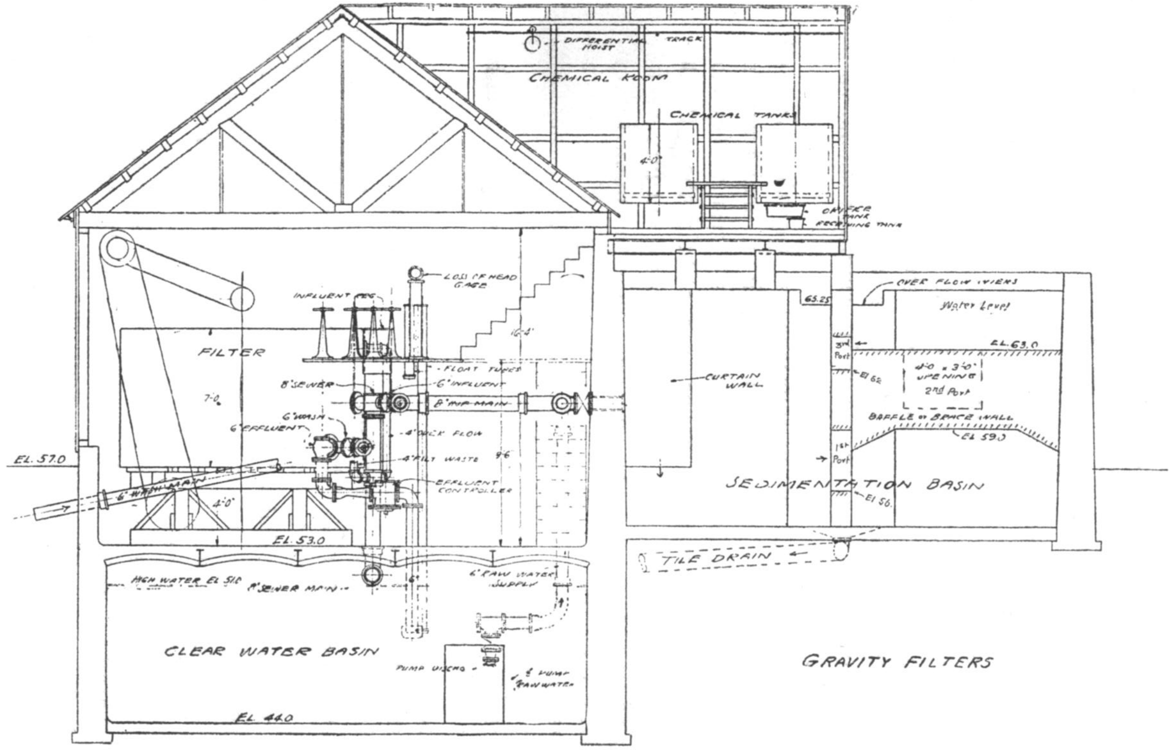

75'0"
Top of Wall El. 67.
Top of wall. El. 66.
Expansion joint
Expansion joints
Note: All Expansion joints to be filled with Asphaltic Cement
El. 54.9
El. 54.5
El 54.5
El. 54.5
Under and over the baffles
Under and over the baffles
A.B.C.D Brace and tie walls Top El. 63
C
D
B
A
35
the basins
Opening 4' wide 3' high bottom at El. 56.0
Opening 4' Wide 3' high bottom at El. 56.0
Opening 4' wide 3' high bot. at El. 63
4 Overflow Weirs El. 65.25
4 - 6" Sluice Openings with flap gates, at bot. El. 54.
3'0"
Sump
4" Reinforced Curtain walls (bot. at El. 57) (Sheet of Expanded metal)
Top. El. 66
General course of flow through
8" Reinforced Concrete floor graded to Sump from each corner and side
12" Vitrified Tile drain bedded in and covered by Concrete
To the filters
10'6"
17'2"
1'6"
2'0"
2'6"
1'0"
15'6"
26'0"
Floor graded toward S.W. Cor.
Opening from bottom - 3' wide by 4' high
CLEAR WATER WELL
6" Concrete floor
Smooth top Coat.
Floor graded toward S.W. Cor.
Opening from bottom 3' wide by 4' high
Centrifugal Pump Concrete foundation 2' deep 3" above floor.
CENTRIFUGAL PUMP ROOM
Foundation (for future pump)
8" C.I. Suction
8" Drain
CLEAR WATER WELL
24'6"
14'2"
14'2"
10'0"
9'0"
14'2"
1'4"
44'0"
8" To pumps
6" C.I. Wash Water line
PLAN OF FOUNDATION AND MAIN WALLS,
SEDIMENTATION BASINS - REINFORCED CONCRETE.
FILTER HOUSE PLAIN CONCRETE
SCALE 1/4" = 1'.
COUNCIL GROVE WATER SUPPLY CO.

PLATE II



ELEVATION

SCALE 1/8"=1

PLATE III

The coagulant is mixed in carefully proportioned quantities and fed through automatic orifice boxes and sight feeds, as experiments show to be best under the differing conditions, at either all possible points, or in any combination or singly (Fig. 3).

1st. At the pump suction; 2d. Inlet to basin No. 1; 3d. At port between basins 2 and 3; 4th. In influent pipe to filters.

From the gravity filters the water passes down to a clear water well in the basement which stores about 40,000 gallons; from this the main water works pumps draw it without lift, delivering into the city system; excess over demand being stored in the standpipe for night use. At the suction inlet there can be given a regulated dose of hypochlorite, if the bacterial condition should seem to require (Fig. 4).

If the new plant should be overburdened at any time and fail to give perfect water, the pumps can drive it in final treatment through the old pressure filter. Tried out as a test this worked effectively. The sedimentation basins (Fig. 5) hold about 125,000 gallons in their 11 feet of depth and can be cleaned out into a sewer which opens from a central overflow and drainage sump, through shear valves, operated from the top of the sump. If all the coagulant was added at one point, either at the inlet, or outlet from the basins, the settled mud in them would be some criterion of action, but as a different condition usually prevails, the regularity of deposit and turbidity is interfered with.

Following the first month of operation, a heavy silt period, the basins were cleaned showing average depths of mud as follows: No. 1, 29 inches; No. 2, 24 inches; No. 3, 16 inches; No. 4, 13½ inches; and frequent washings of the filters were necessary, say four or five times per day. The next month, with better water conditions, indicated mud depths as follows: No. 1, 12 inches; No. 2, 6 inches; No. 3, 5 inches; No. 4, 5½ inches; and much less frequent filter washings, say twice a day, while in January, turbidity was almost nil and filter washings sufficed at twice a week.

During the test days in October, 1914, samples of water were taken at various depths and locations, thoroughly crossectioning the basins, and turbidity readings were compared, indicating the effect of coagulation and subsidence. Even though the water had very slow movement the effect was shown quite handsomely; the minimum turbidity appearing to be between 2 and 4 feet below the surface (Plate IV). At time of these tests, however, the port

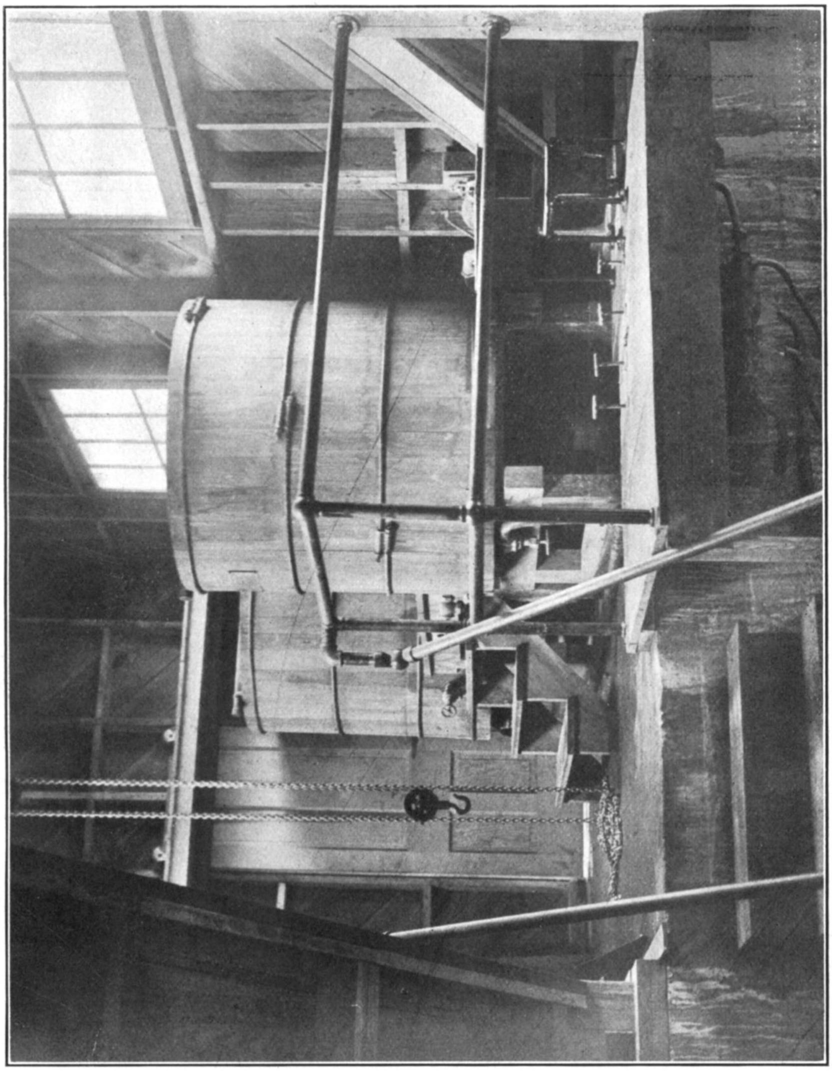


Fig. 3. Alum Tank and Dosing Apparatus before addition of Second Orifice Box

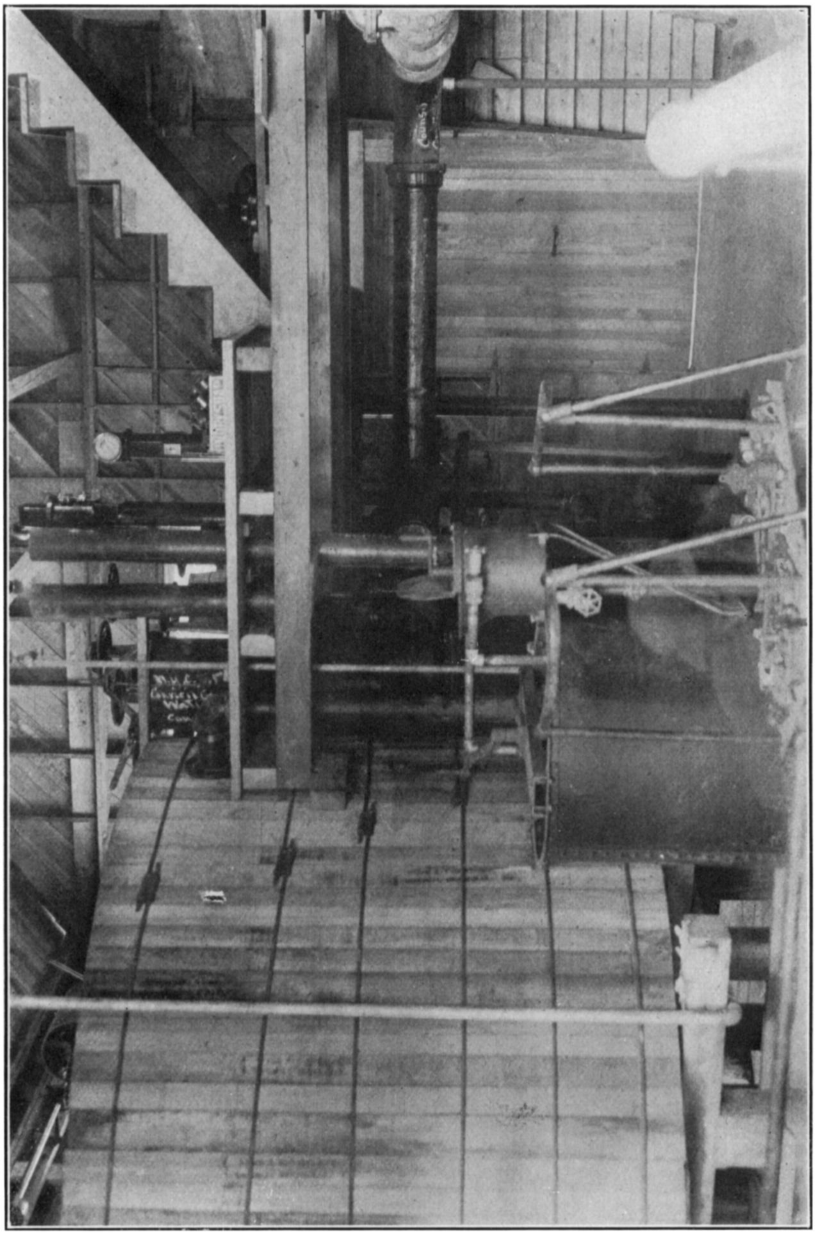


Fig. 4. Filter No. 1, Hypochlorite Tank, Operating Platform

between basins 3 and 4 was near the bottom of the division wall, while since then as described hereinbefore, it was moved to a higher elevation; this will undoubtedly cause some change to be noted in future tests. The use of coagulant, of course, can not be fully standardized before months or even years shall have elapsed, but the point of prime importance is that the plant purifies the raw water. During test days and for some weeks thereafter alum was used in doses as high as 14 and even up to 20 grains per gallon, flood conditions prevailing (Fig. 6), but was soon cut, as experience found to be practicable, to from 4 to 6 grains and now in the winter operation, less than one-half grain is quite sufficient to throw down even the colloids and provide a fine "floc" on the filters for bacterial entanglement. A bright, clear, even sparkling, palatable healthful water is now furnished continuously, where it took mighty faith to even hope for more than comparative clarification from the new plant when it was first planned. (Figs. 7 and 8).

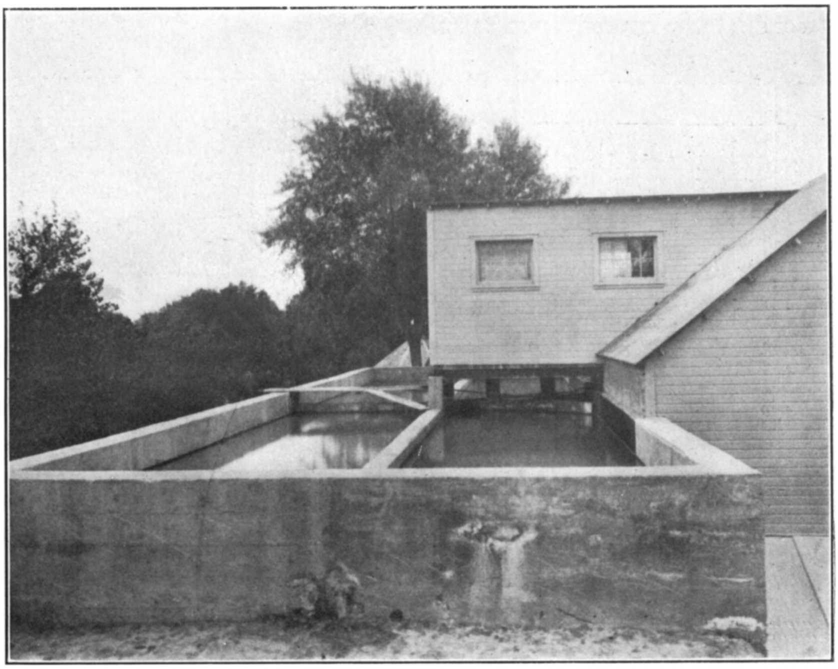
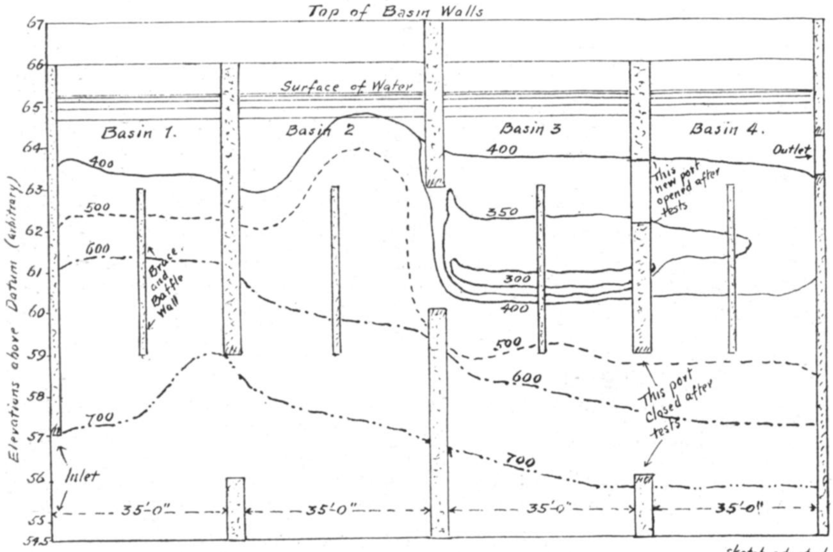


FIG. 5. SEDIMENTATION TANKS AND COAGULATION ROOM

The Kansas laws give a very large measure of authority over water works and sewerage systems and the state Board of Health is very efficient in living up to its duties. After conference, that board accepted the responsibility through its division of water, of conducting the acceptance test of the improved plant, so such acceptance was made a condition in the company's contracts for construction. Mr. C. A. Haskins, engineer of the division of water, and the writer conferred as to many of the matters at interest, and Mr. F. R. Hesser, assistant engineer, was finally assigned to conduct the agreed upon tests.



Isoturbs - in Sedimentation Basins - located from averaged Samples

Sketch adapted from report of F. R. Hesser

PLATE IV

From Mr. Hesser's report December, 1914, the following extracts will be of interest; summing up, as they do very nicely, the mechanical, chemical and bacteriological action of the plant.

> On the night of October 9, a very heavy rain fell in the Neosho Valley above Council Grove and about three feet of water was running over the dam on October 10. The turbidity of the raw water was raised to 1500–1800 parts per million. A portion of this turbidity was so finely divided that a third passage through filter paper failed to remove it. The alkalinity of the raw water was reduced to 50 p.p.m., but the effect of the high turbidity upon the

effectiveness of alum was such that even when 20 grains of alum per gallon of water were being applied, the filtered water had a residual alkalinity of 8.5 p.p.m.

Alum was applied to the raw water at two points in the basins: at the inlet and at the port between basins 2 and 3, while a final dose was applied in the filter influent pipe. The total dose at 12.30 p.m. amounted to 20 grains per gallon. This all passes through one orifice box and it was impossible to determine with any accuracy the amount of the several doses.[1] The lead solution feed pipes were cut and the lower edge spread so that the flow in each could be estimated by eye or actually measured. In this manner, it was estimated that both points in the basin were receiving about 8 grains each, while the influent dose was about 4 grains.

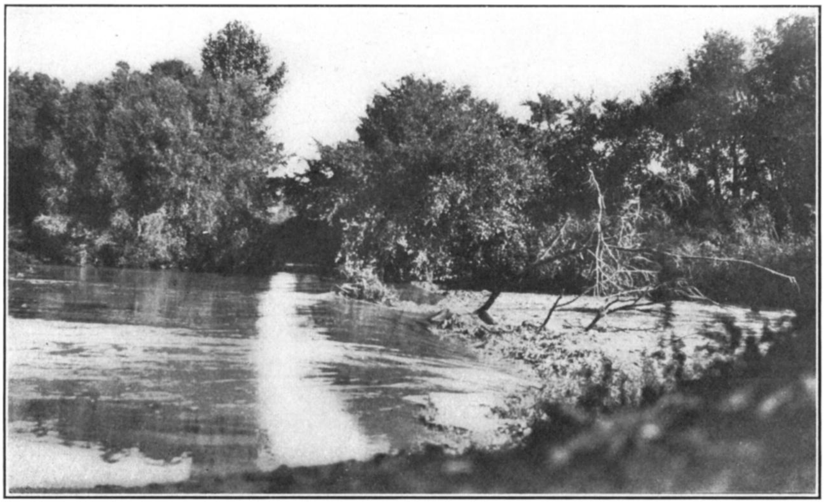


FIG. 6. NEOSHO RIVER. THIRTY-INCH FLOOD PASSING OVER MISSION DAM. SEVENTEEN YEARS OF FLOODS UP TO SIXTEEN FEET IN DEPTH HAVE PASSED OVER THIS DAM WITHOUT CAUSING MATERIAL INJURY

A very finely divided floc was at times noticeable at points in the basin, but did not seem to effect a noticeable sedimentation. That complete reaction was prevented seems clear from the fact that the settled water in basin 4 had a residual alkalinity of 35 p.p.m. The turbidity of this water which passed on to the filters was about 950 and the dose of approximately 4 grains of alum per gallon produced no visible or effectual floc, the finely divided turbidity passed completely through the filter, resulting in a final turbidity of 500 p.p.m. and an alkalinity of 20 p.p.m. At 3.30 p.m., however, a slight, pin floc appeared on the filters and this rapidly increased to heavy flakes, which settled rapidly. The filter effluent at once became clearer until at 5 p.m. the turbidity of filtered water was approximately 10 p.p.m. This production of floc was accompanied by a rapid reduction of alkalinity, the filter effluent at 5 p.m. having 8.5 p.p.m. of alkalinity.

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[1] After the tests a second orifice box was installed. L.L.T.

The total alum dose was now reduced to 14 grains per gallon and filtration proceeded satisfactorily until the day's run was closed at 6.30 p.m.

Tables I and II show the results of determinations made during the day, with the exception of special determinations shown by tables entitled, "Turbidity Readings."

TABLE I

		ALKALINITY	TURBIDITY
Raw water at 10.30 a.m.	Oct. 10, 1914	50	1500
Settled water, basin 4	10.30 a.m.	63	—
Settled water, basin 4	11.15 a.m.	44	750
Filtered water	11.15 a.m.	46	600
Settled water, basin 4	12.30 p.m.	35	950
Filtered water	12.30 p.m.	20	500
Filtered water	3.30 p.m.	18	50
Filtered water	3.45 p.m.	14	50
Filtered water	5.00 p.m.	8.5	10

TABLE II

(Extracts from Table I)

Date: Oct. 10, 1914.

Time: See Table.

Alum dose: About 8 grains at inlet; 8 grains between basins 2 and 3; 4 grains on filters.

SAMPLE	TIME	TURBIDITY
Raw water	10.30 a.m.	1500
Basin No. 4	11.15 a.m.	750
Filtered water	11.15 a.m.	600
Basin No. 4	12.30 a.m.	950
Filtered	12.30 a.m.	500

Tables III and IV show the results of some special determinations made at this time. Samples taken from the river and from the outlet ends of the four compartments, with the results, are shown in Table III. It is evident that the heavier suspended matter has remained near the bottom of compartment 1, but is gradually brought nearer the surface as the water flowed through the basins.

In order to learn, if possible, the path of maximum turbidity through the basin and the effect of the tie walls and ports upon the path, I decided to take samples at various depths in several planes across each compartment, determine the turbidity of each and thus be enabled to plot the lines of equal turbidity both in plan and elevation, from inlet to outlet. Samples were to be taken at depths of 1 foot, 5 feet and 10 feet or at intermediate points where sharp differences in turbidity were noted. To collect the samples, an 8 ounce drug bottle was securely fastened to the end of a 12-foot pole and a cork was attached to a string, by which it could be removed from the bottle when the bottle had been submerged to the proper depth. A Jackson Turbidimeter tube was used with an electric battery and 1 candle power bulb, in place of the standard candle. Before determining the turbidity of individual samples, an average sample was taken from each compartment as follows: An 8-ounce sample was taken at each sampling point at depths of 1 foot, 4½ feet and 8½ feet. Equal volumes of each of the 27 samples thus taken in each compartment were combined to form an average sample of that compartment.

Table IV shows the results obtained. It will be noted that the average turbidity in basin 2 is higher than in 1; that basin 3 shows a reduction of 45 per cent from No. 2 and 35 per cent from No. 1; while No. 4 has an average turbidity higher than that of the first compartment.

The examination of individual samples was taken up about 3 p.m. October 10, but had to be discontinued before the first compartment was completed, because of the burning out of the bulbs used in the flash light. A candle turbidimeter was not at hand and the work could not be completed. On October 12, however, Mr. Tribus took samples at the previously described points from depths of 2 feet, 4 feet, 6 feet and 8 feet. The three samples for each depth on each horizontal line across the compartment were mixed and the resultant turbidity determined approximately by comparison with that of bottled samples previously examined with the turbidimeter. These results are shown in Table V.

Plate IV is a group of curves showing the variation in turbidity along each level, in a diagram of the basins developed along the line of flow, and the probable lines of equal turbidity as determined by the limited data of Table V. This merely illustrates the possibilities of this method of studying basins where sufficient data are obtained.

It was obvious that the basin as arranged was not efficient. The mud evidently settled to the floor, but the depth of the ports between compartments 1 and 2 and 3 made it possible for the most turbid water to be carried through the ports, impinge on the opposite wall and rise in a boil near the center of the basin. These boils were, in fact, visible in basins 2 and 4. It was, therefore, thought best to close the port between No. 3 and No. 4 and cut a new one 4 feet wide by 1.5 feet high, with its bottom 8.5 feet above the basin floor. This change had been made at the time of the last visit but the low turbidity of the raw water made it impossible to determine what its effect may be.

The basins are designed to give a 6-hour retention period on the basis of 500,000 gallons filtered per 24 hours. The actual period is probably approximately 4.5 to 5 hours.

TURBIDITY READINGS

TABLE III

Date: Oct. 10, 1914.
Time: 12.30 p.m.
Raw water: Turbidity 1500.
Alum dose: 8 grains at inlet, 8 grains between basins 2 and 3; 4 grains on filters.

	Sample	*Turbidity*
Basin No. 1.	Outlet end, 1 foot depth	340 p.p.m.
Basin No. 2.	Outlet end, 1 foot depth	675 p.p.m.
Basin No. 3.	Outlet end, 1 foot depth	925 p.p.m.
Basin No. 4.	Outlet end, 1 foot depth	1000 p.p.m.
Water on Filters		900 p.p.m.
Filter Effluent		500 p.p.m.

TABLE IV

Date: Oct. 10, 1914.
Time: 3 p.m.–4 p.m.
Raw water: Turbidity—1500.
Alum Dose: Same as above.

	Sample	*Turbidity*
Basin No. 1.	Average Sample	650 p.p.m.
Basin No. 2.	Average Sample	750 p.p.m.
Basin No. 3.	Average Sample	420 p.p.m.
Basin No. 4.	Average Sample	700 p.p.m.

TABLE V

Date: Oct. 12, 1914.
Results reported by Mr. Tribus.
Raw Water Turbidity:—750.

BASIN	SAMPLE	DEPTH OF SAMPLE			
		2 feet	4 feet	6 feet	8 feet
1	1 (a)	520	600	615	700
	1 (b)	410	610	615	
	1 (c)	400	600	700	
2	2 (a)	340	580	625	700
	2 (b)	510	535	615	
	2 (c)	480	550	625	
3	3 (a)	375	330	515	650
	3 (b)	375	325	500	
	3 (c)	375	325	535	
4	4 (a)	390	350	525	600
	4 (b)	390	350	525	
	4 (c)	400	400	550	

RESULTS AND RECOMMENDATIONS

CHEMICAL DOSING AND ACTION

Determinations made November 16, 17 and 18 show a practically normal alkalinity reduction per grain of alum. The dosage was as follows: During the morning of November 16, 2.6 grains of alum per gallon introduced at the inlet to basin No. 1, and 2.3 grains in the influent pipe. Not much floc on basin No. 1 but good in the following basins. Very heavy floc on the filters. At noon, the influent dose was reduced to 1.1 grains per gallon and the raw water dose applied to the pump suction instead of inlet well. A good floc soon appeared in basins, due probably to better mixing in the pump, and carried completely around them. At 10.15 a.m. the pump suction dose had been reduced to 1.6 grains per gallon and a fair floc continued to appear in basin No. 4. With the low turbidity existing at this time, clarification in the basins is not the object sought by coagulation, but the formation of a schumtzdecke on the filters.

It seems probable that by applying a dose of about 1 to 2 grains per gallon between basins 2 and 3, the influent dose might be dispensed with, except for perhaps two hours after starting a new run. At 7.30 a.m., November 18, the raw water dose of 1.6 grains was changed to the port between basins 2 and 3, and 1 grain per gallon was applied to the influent pipe for two hours and then cut out. Samples taken at 10.30 and 11.00 a.m. showed very satisfactory bacterial counts, but can hardly be taken as strictly representative samples, since only 3 hours had elapsed since making the change.

The results of alkalinity and turbidity determinations and bacterial plates made during the test run of November 16, 17 and 18 are reviewed as follows. The filters had been washed at 5.30 p.m. November 15 and allowed to stand idle over night. The sand beds were agitated slightly by the rakes the following morning and the run started at 7.30 a.m.

The first samples were taken from the controller petcocks at 9.15 a.m. and at frequent intervals thereafter. Filter No. 1 was washed thoroughly at 9.25 a.m. and was then operated continuously, except for washing periods until 11.15 a.m. November 17, and the bacterial counts in samples taken from No. 1 during its run are very satisfactory, the maximum being 75 per cc. and the minimum 12 per cc. The samples taken from the power house tap and from No. 2 are not so good, but it must be remembered that No. 2 filter was being subjected to drop tests during the time and the consequent rough treatment doubtless increased the bacterial count in its effluent, as well as in the combined effluent of Nos. 1 and 2. After 11.15 a.m., November 17, filter No. 1, was also being subjected to drop tests. Filter No. 2 was washed at 10.15 a.m. November 18 and both filters operated uniformly until 11.00 a.m. The sample then taken from the power house tap, and that from the Controller No. 1 show satisfactory counts. Samples of raw, coagulated and filtered water from the power house tap were collected at noon, November 18, and shipped to the laboratory where they were plated and fermentation tubes inoculated. The results indicate a satisfactory effluent.

The results indicate that a 5-minute period of filtering to waste after washing will give a satisfactory effluent during periods of low turbidity. The alum

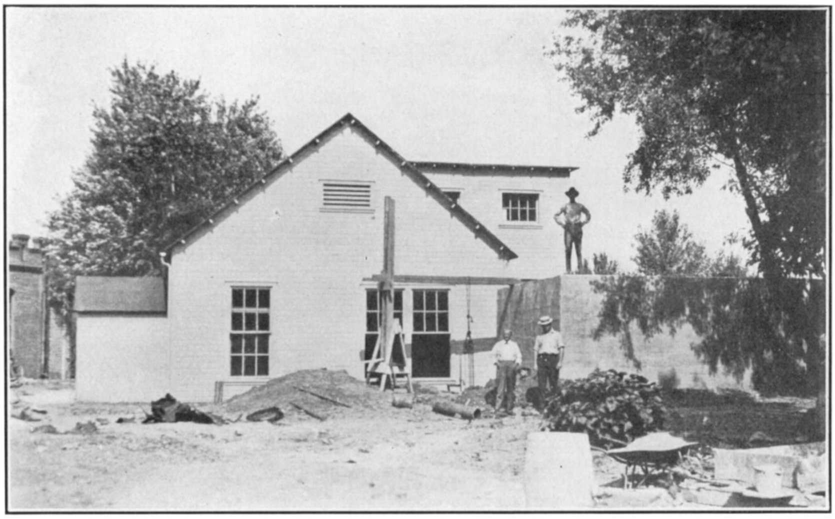


FIG. 7. FILTER HOUSE AND SEDIMENTATION BASINS FROM THE SOUTHEAST

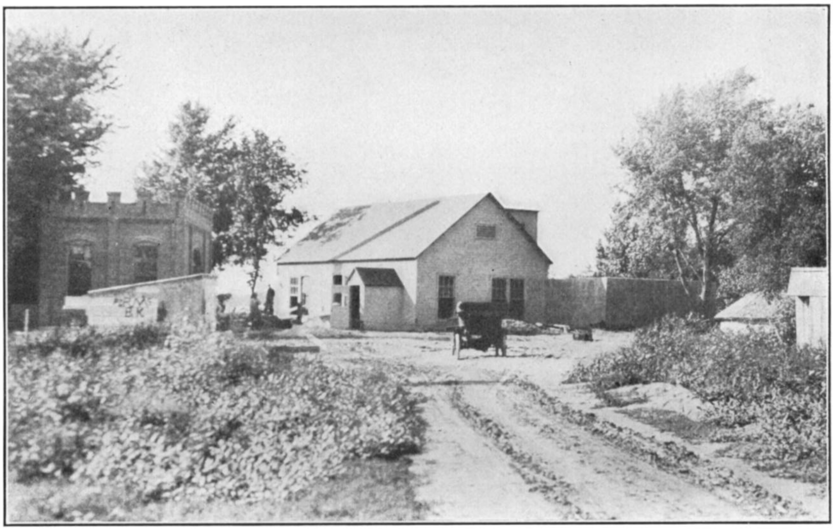
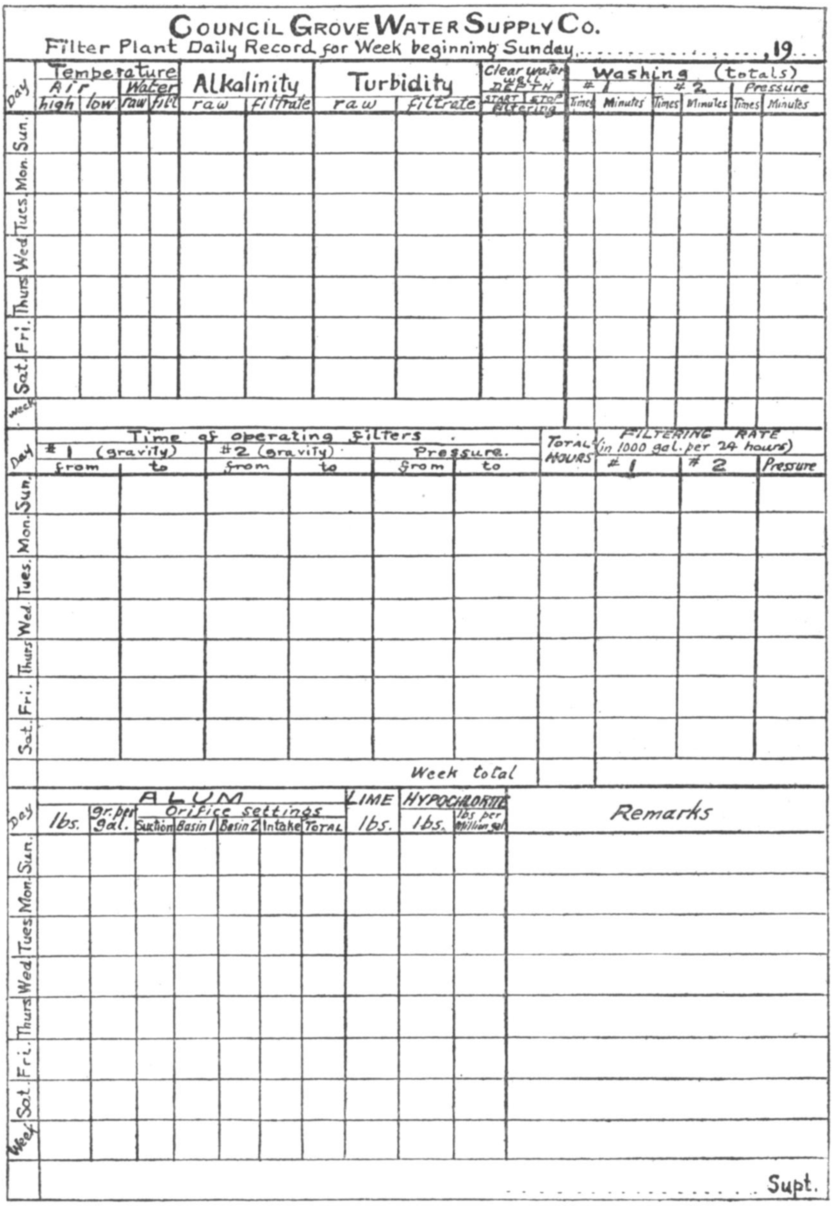


FIG. 8. OLD (BRICK) FILTER ROOM—NEW FILTER HOUSE AND SEDIMENTATION BASIN AND RIVERSIDE INTAKE WELL. (FROM SOUTH)



COUNCIL GROVE WATER SUPPLY CO.

Filter Plant Daily Record for Week beginning Sunday........................, 19..

Day	Temperature				Alkalinity		Turbidity		Clear water well DEPTH		Washing (totals)					
	Air		Water								#1		#2		Pressure	
	high	low	raw	filt	raw	filtrate	raw	filtrate	START filtering	STOP filtering	Times	Minutes	Times	Minutes	Times	Minutes
Sun.																
Mon.																
Tues.																
Wed.																
Thurs.																
Fri.																
Sat.																
week																

Day	Time of operating filters						TOTAL HOURS	FILTERING RATE (in 1000 gal. per 24 hours)		
	#1 (gravity)		#2 (gravity)		Pressure.					
	from	to	from	to	from	to		#1	#2	Pressure
Sun.										
Mon.										
Tues.										
Wed.										
Thurs.										
Fri.										
Sat.										
	Week total									

Day	ALUM							LIME	HYPOCHLORITE		Remarks
	lbs.	gr. per gal.	Orifice settings					lbs.	lbs.	lbs per Million gal	
			Suction	Basin 1	Basin 2	Intake	TOTAL				
Sun.											
Mon.											
Tues.											
Wed.											
Thurs.											
Fri.											
Sat.											
Week											

.... Supt.

FIG. 9

> dose probably may safely be reduced to 1 grain per gallon introduced between compartments 2 and 3, with a secondary dose of ¾ to 1 grain per gallon in the influent line for two hours after starting a run during such period of low turbidity. A marked decrease in the raw water temperature from that noted during the test, 6 degrees C., may necessitate the introduction of the dose at the pump suction.
>
> During periods of high turbidity, it will be necessary for the operator to experiment with the amount and points of introduction of the alum dose, in order that a method of treatment which will effect the most economical and efficient coöperation between settling basin and filters may be obtained. Turbidity and alkalinity readings should be taken daily or oftener and the amount of doses and points of application recorded for future guidance.
>
> Until absolute certainty in operation is attained, hypochlorite should be kept on hand and used in doses of 8 to 10 pounds per million gallons filtered, whenever there is any question as to the quality of the effluent. I believe that the filters are capable of delivering a pure and wholesome effluent with proper operation, and I recommend that they be accepted on condition that adequate effluent controllers be provided.

The engineers of the filter manufacturers, the Kansas State Board of Health and Messrs. Alvah Smith and Arthur E. Smith (the latter representing the writer's firm on the work) all took a very active and helpful interest during design, construction and testing.

As the water company may find possible, without undue expense, further testing will be carried out, while constant record will be kept of the more salient features that may prove helpful also in the treatment of other western waters.

The forms for daily records (Fig. 9) are not as complete as would be the case if a much larger plant was involved and a chemist kept employed, but the very careful superintendent (Mr. A. Moser, Jr.) has already done much experimenting, and engineers from the Kansas State Department of Health, Division of Water, will make frequent visits and make bacteriological tests from samples then taken, so that the station may quite well become of value, not alone to Council Grove, but in helping to solve some of the trying problems of water purification.